Variety, Price, and Consumer Desirability of Fresh Fruits and Vegetables in 7 Cities around the World

Variety, Price, and Consumer Desirability of Fresh Fruits and Vegetables in 7 Cities around the World

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ABSTRACT

Few studies have attempted to quantify the variety, price, and consumer desirability of fruits and vegetables (F&Vs) across a diversity of cities. We implemented a market basket survey of F&Vs from December 2018 to February 2019 in middle-income neighborhoods of the following cities: Visakhapatnam, India; Kathmandu, Nepal; Addis Ababa, Ethiopia; Dar es Salaam, Tanzania; Mexico City, Mexico; Bangkok, Thailand; and Brookline, United States. The total variety of fruits ranged from 4.1 in Visakhapatnam to 17.3 in Brookline, and of vegetables from 6.1 in Dar es Salaam to 20.3 in Brookline. Of the 3 fruits for which price data were collected, apples tended to be the most expensive, and bananas the least expensive. For vegetables, capsicum tended to be the most expensive and eggplants the least expensive. Tablet-based market basket surveys are a useful tool for evaluating food environments. These pilot data provide further evidence of the homogenization of global diets. *Curr Dev Nutr* 2019;3:nzz085.

An estimated 18% of adults in low- and middle-income countries (LMICs) (1) meet the WHO recommended intake level of 400 g of fruits and vegetables (F&Vs) per day—the equivalent of approximately 5 servings (2). Even in the United States, the Centers for Disease Control and Prevention estimates that only 9% of the US adult population meets this recommendation (3). These low numbers are especially concerning as we reach the midway point of the UN Decade of Action on Nutrition (2016–2025) given that low intake of F&Vs is associated not only with obesity, diabetes, and other diet-related noncommunicable diseases (4, 5), but also with undernutrition (6, 7).

Price has been implicated as the primary barrier to increasing intake of F&Vs, but recent local data from cities around the world on the price of F&Vs are limited. Given that F&Vs are highly perishable and less tradable, their price is more dependent on local productivity and value chains compared with other food products (8, 9). Moreover, given today's urbanizing and changing environment—in terms of politics, economies, and climate—the rapid, up-to-date collection of such data will be critical for developing contextually appropriate policies to promote intake. Several previous studies have used data on national average food prices (e.g., not vendor-level data) routinely collected by governments to estimate the cost of nutritious diets, for example, the Indicators of Affordability of Nutritious Diets in Africa (IANDA) project in Tanzania, Ghana, and the South Asian region (10, 11). In addition, the Prospective Urban Rural Epidemiology (PURE) study collected nonsale prices of F&Vs from grocery stores and market places in 18 countries between 2009 and 2013 (12). PURE found that the cost of each individual in a household meeting the WHO recommendation (5 servings per day) as a proportion of that household's income was 2% in high-income countries compared with 52% in low-income countries (12).

In addition to price, we propose that the variety and consumer desirability of available F&Vs can be important drivers of their intake. Indeed, previous studies in the United States have found that consumer perceptions of the quality of F&Vs are positively correlated with their intake (13) and that bruising, loss of firmness, and unpleasant aroma are deterrents to purchasing F&Vs (14). However, to the best of our knowledge, no studies have explored all of these metrics in multiple countries. To address this gap, we implemented a market basket survey

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Abbreviations used: F&V, fruit and vegetable; IANDA, Indicators of Affordability of Nutritious Diets in Africa; LMICs, low- and middle-income countries; PURE, Prospective Urban Rural Epidemiology.

TABLE 1 Characteristics of a convenience sample of cities in 7 countries and summary of vendors selling fresh fruits and vegetables

Location	Population density (per km^2)[1]	Average income or GDP per capita-PPP (USD)[2]	Total number of vendors selling fruits or vegetables in 1-km radius	Supermarket, % (*n*)	Small stationary vendor, % (*n*)	Mobile vendor, % (*n*)	Other, % (*n*)
Overall	NA	NA	130	16.2 (21)	58.8 (76)	19.2 (25)	6.2 (8)
Brookline, United States	3360	$65,189	3	100 (3)	0	0	0
Mexico City, Mexico	6071	$39,860	12	33.3 (4)	16.7 (2)	0	50.0 (6)
Bangkok, Thailand	3644	$9396	7	57.1 (4)	42.9 (3)	0	0
Visakhapatnam, India	6291	$7059	31	12.9 (4)	35.5 (11)	48.4 (15)	3.2 (1)
Kathmandu, Nepal	4416	$2764	40	5.0 (2)	75.0 (30)	20.0 (8)	0
Addis Ababa, Ethiopia	5198	$1899	17	17.6 (3)	82.4 (14)	0	0
Dar es Salaam, Tanzania	3133	$2946	20	5.0 (1)	80.0 (16)	10.0 (2)	5.0 (1)

[1]Sources: United States Census Bureau, 2010 (32); Instituto Nacional de Estadística y Geografía, 2015 (33); World Bank, 2009 (34); India Office of the Registrar General & Census Commissioner, (35); Nepal Central Bureau of Statistics, 2011 (36); Ethiopia Central Statistical Agency, 2007 (37); Tanzania National Bureau of Statistics, 2012 (38). NA, not applicable; PPP, purchasing power parity.
[2]Sources: United States Census Bureau, 2010 (32); OECD, 2018 (39); OECD, 2013 (40); World Bank (41); Government of Nepal National Planning Commission (42).

of F&Vs in a convenience sample of cities in 7 countries: the United States, Mexico, Thailand, India, Nepal, Ethiopia, and Tanzania. To reduce seasonal effects that could influence comparisons across these diverse settings, all data were collected within a 3-mo window spanning December 2018 to February 2019.

The survey was adapted from the Nutrition Environment Measures Survey for Stores (15) and the Produce Desirability Tool by Montana State University (16). It included information on vendor type and the availability, nonsale price (i.e., retail price before any discounts), and consumer desirability of 8 specific F&Vs: bananas, apples, mangoes, spinach, sweet potatoes, capsicum, eggplants, and tomatoes. These 8 F&Vs were chosen based on discussions with colleagues in each of the countries and were identified as the most commonly available, nutrient-dense F&Vs across these diverse cities (e.g., we chose "spinach" over "cabbage" because although cabbage is more common across these cities, spinach is a vitamin A–rich green leafy vegetable). However, although we collected detailed information on price and consumer desirability only for these 8 F&Vs, we collected information on availability of every F&V at every vendor. Vendors were classified as follows: large, indoor, self-serving stores selling food products were categorized as "supermarkets"; small structured spaces were categorized as "small stationary vendors"; and individuals or small groups of individuals selling in stalls, from cars, bicycles, or on the side of the road were categorized as "mobile vendors." Consumer desirability was assessed on a Likert scale ranging from 1 to 6, with 6 being the highest overall quality (16). F&Vs were scored as high quality if they had favorable characteristics in terms of touch, smell, appearance, and size (16).

The survey was administered in a 1-km radius area in middle-income neighborhoods of the following 7 cities: Visakhapatnam, India; Kathmandu, Nepal; Addis Ababa, Ethiopia; Dar es Salaam, Tanzania; Mexico City, Mexico; Bangkok, Thailand; and Brookline, United States. These cities were selected to capture variability in country income level and world region. The buffer area was defined by selecting an F&V market in a middle-income neighborhood and drawing a 1-km radius around the market in Google Maps. The study received a determination of "Not Human Subjects Research" by the institutional review board of the Harvard T.H. Chan School of Public Health on 11 December 2018 (protocol number: IRB18-0791).

Implementation was such that a survey was completed for every establishment within the study area (i.e., the 1-km buffer area) that sold fruits and/or vegetables (either retail or wholesale) at the time and place of sale. The survey questions were answered directly by the surveyor without communication with the vendor, unless the price was not displayed in which case a local translator assisted in asking for the market price of the items of interest. Open markets with multiple individuals selling produce were surveyed as 1 vendor. If a vendor was selling >1 variety of a given fruit or vegetable (e.g., multiple different varieties of apples), the least expensive variety was used for the survey. Across all cities, 130 surveys were completed.

Variety was calculated by counting the total number of different types of F&V available at each vendor. The price of each food was converted from reported units, such as price per banana, to price per unit of weight (kg) and then converted to a common currency (USD). For any item that was not sold as price per gram or kilogram, reported average weights were derived from kilogram equivalents for a medium-sized item as reported by the US Department of Agriculture. To facilitate comparisons across countries, we used World Bank exchange rates for 2013 (USD to NPR, INR, ETB, TZS, THB, and MXN of 93.58, 58.60, 17.70, 1600.44, 30.73, and 12.77, respectively).

Kathmandu had the greatest density of vendors selling fruits or vegetables, with 40 within a 1-km radius, whereas Brookline had the lowest density, with just 3 within a 1-km radius (**Table 1**). This was not surprising given that an estimated 88% of Americans drive to

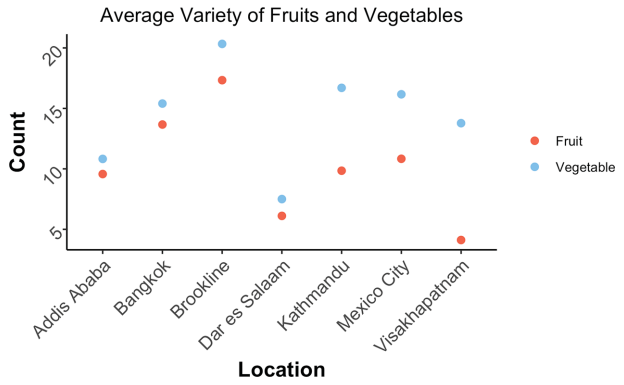

FIGURE 1 Average variety of fruits and vegetables across all vendors selling fruits or vegetables in a 1-km radius area in a convenience sample of cities in 7 countries.

purchase their food (17), rather than walking to a vendor in their residential neighborhood, which can be a more common practice in LMICs. Supermarkets were most common in cities in higher-income countries (Brookline, Bangkok, and Mexico City), with 100% of vendors in Brookline being supermarkets, whereas the majority of vendors surveyed in cities in lower-income countries (Kathmandu, Addis Ababa, and Dar es Salaam) were small stationary vendors. In Visakhapatnam, mobile vendors were most frequently selling F&V.

Overall, across all 7 cities, we recorded 33 different types of fruits and 36 different types of vegetables (**Supplemental Table 1**). The total variety of fruits by city ranged from 4.1 in Visakhapatnam to 17.3 in Brookline (**Figure 1**). Brookline also had the highest average variety of vegetables among the 7 cities, at 20.3 vegetables per vendor, whereas Dar es Salaam had the lowest average variety of vegetables, with 6.1 vegetables per vendor. Bananas and oranges were the most frequently sold fruit, with 77.5% of vendors across all 7 cities selling them (Supplemental Table 1, **Table 2**). Mangoes were the least frequently sold of the 3 specific fruits (bananas, apples, and mangoes), with only 32.4% of vendors selling them (Table 2), although there were several fruits that were sold by <5% of vendors, including many berries (blackberry, blueberry, raspberry), litchi, honeydew, kumquat, persimmon, plum, apricot, and jackfruit (Supplemental Table 1). Tomatoes were the most frequently sold vegetable, with 94.5% of vendors selling them (Table 2), and onion, cabbage, and carrots were all sold by >80% of vendors (Supplemental Table 1). Only 35.6% of vendors sold sweet potatoes, making them the least commonly sold vegetable of the 5 specific vegetables for which we collected in-depth data (Table 2), although several other vegetables were sold by <5% of vendors including turnip, leek, chard, radicchio, rutabaga, jicama, and brussels sprout (Supplemental Table 1).

We did not observe substantial variability in consumer desirability across F&Vs (Table 2), suggesting that more sensitive measures of this determinant of purchasing and intake could be required. Based on a scale from 0 (not desirable) to 6 (most desirable), the F&Vs with the highest overall desirability were capsicum (4.36), spinach (4.35), apple (4.12), and sweet potatoes (4.12). The F&Vs with the least overall desirability were eggplants (3.97) and mangoes (4.09). All values were higher than the average score for all produce evaluated in a study using the same tool in Montana, United States (mean ± SD: 3.5 ± 0.7) (16).

Of the 3 fruits for which in-depth price data were collected (apples, bananas, and mangoes), apples tended to be the most expensive fruit per kilogram, and bananas the least expensive (**Figure 2**). The average price for a kilogram of apples ranged from $1.43 in Kathmandu to $6.96 in Addis Ababa, whereas the average price for a kilogram of bananas ranged from $0.46 in Kathmandu to $2.84 in Brookline. For vegetables, capsicum tended to be the most expensive per kilogram and eggplants the least expensive, with spinach and tomatoes being a similar price per kilogram. The average price per kilogram varied across location most for apples and spinach whereas the price varied least for bananas and

TABLE 2 Average availability, price, and consumer desirability of 8 common fruits and vegetables in a convenience sample of cities in 7 countries (the United States, Mexico, Thailand, India, Nepal, Ethiopia, and Tanzania). Results by city are presented in **Supplemental Tables 2–8**

	Vendors selling item, % (*n*)	Price per kg (USD),[1] mean ± SD	Overall desirability of item,[2] mean ± SD
Fruits			
Banana	77.5 (79)	1.22 ± 0.57	4.09 ± 1.17
Apple	63.7 (65)	3.03 ± 1.81	4.12 ± 0.89
Mango	32.4 (33)	2.07 ± 1.26	4.09 ± 1.09
Vegetables			
Spinach	46.6 (34)	2.13 ± 1.48	4.35 ± 1.20
Sweet potato	35.6 (26)	1.86 ± 1.40	4.11 ± 1.07
Capsicum	75.3 (55)	2.92 ± 2.50	4.36 ± 1.18
Eggplant	49.3 (36)	1.49 ± 1.76	3.97 ± 1.11
Tomato	94.5 (69)	1.38 ± 1.39	4.10 ± 0.86

[1]When price was collected per item, it was converted into per kilogram using the standard weight of the medium size of the item per the US Department of Agriculture: 0.118 kg per banana; 0.182 kg per apple; 0.336 kg per mango; 0.340 kg per bunch of spinach; 0.130 kg per sweet potato; 0.119 kg per capsicum; 0.548 kg per eggplant; 0.123 kg per tomato. Local currency values were converted into USD equivalents based on 2013 data from the World Bank.
[2]Response to "Overall, how desirable is this banana compared to your perception of a high-quality banana?" ranging from 0 (not desirable) to 6 (most desirable).

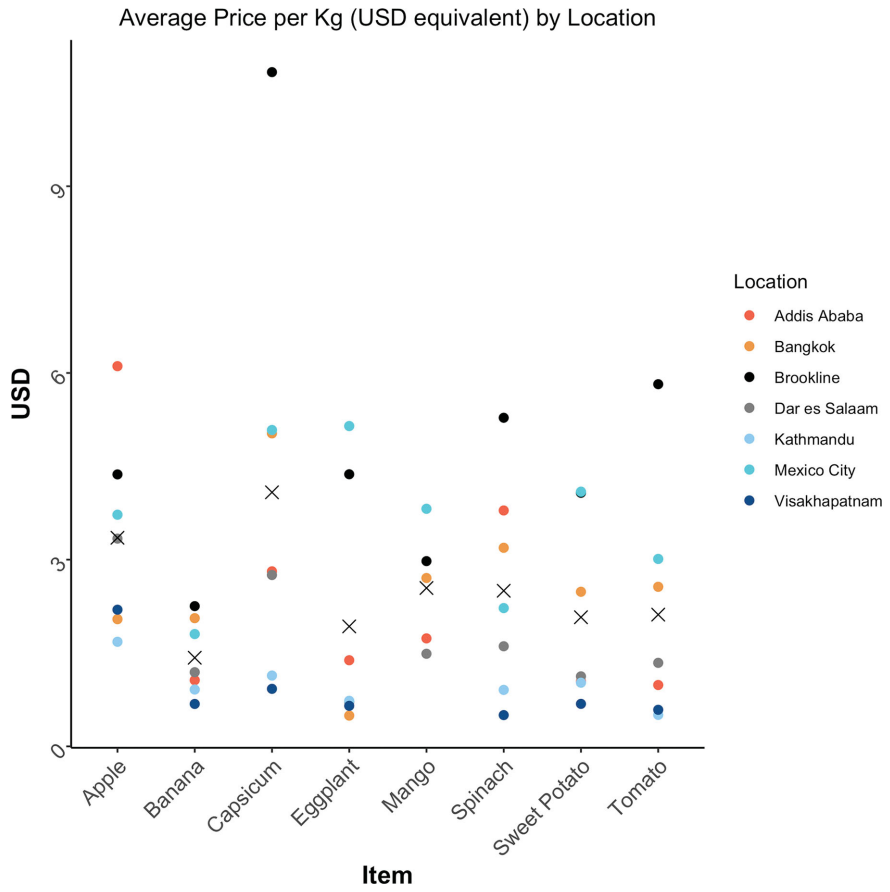

FIGURE 2 Average price per kilogram (USD equivalent) for fruits and vegetables in a convenience sample of cities in 7 countries. Data points reflect city mean values whereas 'X' reflects the overall sample mean.

tomatoes. For bananas, eggplants, mangoes, and tomatoes we found that Brookline was the location where prices were greatest. Average prices per kilogram in Visakhapatnam were consistently <$1.00 for all items surveyed. In Kathmandu, average price per kilogram was <$1.00 for all produce excluding apples, for which the average price was $1.43/kg.

Comparing the average price for Dar es Salaam found in our study, conducted in 2019, with the national price reported by the IANDA group for Tanzania in 2011, we found that our price was lower for all F&Vs evaluated, with the biggest price difference for apples and only slight differences for sweet potatoes, spinach, and tomatoes (10). Comparing the average F&V prices observed in Brookline with US Department of Agriculture average prices for 2018 (18) indicated that produce prices in Brookline are higher than national averages, with the most substantial difference observed for capsicum, for which the average price in Brookline was $10.38/ kg whereas the national average was $3.28/kg. Thus, results for Brookline should not be interpreted as generalizable to the US population.

Using the price of the lowest-price F&Vs in each city, we calculated the estimated lowest cost to meet the WHO 400 g/d recommendation (assuming two 80-g servings of fruits and three 80-g servings of vegetables). In absolute terms, the estimated daily cost of meeting the WHO recommendation was highest in Brookline ($1.34) and lowest in Visakhapatnam ($0.23) (**Supplemental Table 9**). However, as a proportion of estimated average daily income for residents, the cost of meeting the WHO recommendation was highest in Addis Ababa—the poorest of the cities—at 7.8% of income, and lowest in Brookline—the richest of the cities—at 0.7% of income.

This study, despite being limited by the small, convenience sample of just one, 1-km radius area in 7 cities around the world, provides valuable, novel information on access to F&Vs. It is surprising given the diversity of cities included that there was little heterogeneity in the varieties of F&V available: nearly all vendors were selling tomatoes, bananas, capsicum, and apples, and about half were selling spinach and eggplants. The overall dearth of variety in F&Vs available, particularly in LMICs compared with the US city, which had the highest total variety, emphasizes the need to nourish diversity in local food systems around the world. The preponderance of small stationary vendors as the source of F&Vs—rather than supermarkets—in LMICs suggests that strategies to promote intake of F&Vs could differ from those used in high-income settings.

This study was also limited by the fact that data were collected within a single 3-mo window spanning December to February. Previous research on the seasonality of F&Vs in LMICs has largely been limited to rural areas, with intake of F&Vs tending to be higher during rainy/monsoon season compared with the dry/postmonsoon or winter season (19, 20), though not in all studies (21). Two recent studies in

Shanghai, China, found that intake of F&Vs was highest in the summer, with particularly striking differences for fruits (22, 23). In contrast, a study in Ethiopia found little seasonal variability in intake of F&Vs in urban areas (24). Similarly, a small study conducted in Rio de Janeiro, Brazil, did not find significant differences in intake of vitamin C between summer and winter (intake of F&Vs not reported) (25), and a small study in Washington DC, United States (the first such broad analysis of seasonality in a US metropolitan area), found no significant differences in intake of F&Vs across seasons (26). Future studies should aim to quantify the effects of seasonality in cities, particularly in LMICs, where there might be less fluctuation in the availability of these products. They could also consider exploring variability in the measured parameters *within* cities.

The WHO and FAO launched a joint initiative to promote F&Vs in 2003 (27), yet 15 y later, little progress has been made and a second meeting has not been convened. In addition to the environmental factors evaluated in this study, individual factors such as poor nutritional knowledge or culinary skills can also impede fruit and vegetable intake. However, a recent simulation study found that a 1-y mass media campaign ("5-a-day campaign") would only increase US average national F&V intake by 7% compared with a 14% increase observed with a 10% decrease in F&V prices; thus, price reductions are likely to be a more powerful tool for improving F&V intake than education interventions (28). Lending further support to this, a recent Cochrane review identified 55 interventions designed to increase F&V intake among children—only 14 of which were judged to be free from high risk of bias—and concluded that the evidence is sparse to support nutrition education for F&V promotion in this population (29). Overall, evidence regarding the effectiveness of interventions to promote F&Vs in LMICs, where food safety concerns can add complexity to implementation, is severely limited. A recent qualitative policy analysis in India highlighted 3 specific opportunities for F&V promotion: *1*) innovations in production, transport, and retail using public-private partnerships; *2*) leveraging existing synergies across the agriculture, economic, and health sectors; and *3*) joint efforts from agriculture and health sectors to collect more and better data to evaluate the impacts of policies on F&V intake (30).

The results presented herein can serve as a foundation for future work on the availability and price of F&Vs, particularly in megacities of the developing world, considering that 68% of the world's human population will live in cities by 2050 (31). The survey tool enables rapid, mobile phone– or tablet-based data collection, and could be used to greatly expand our knowledge of the food environment as it relates to F&Vs. Moreover, such observational scans or audit tools can be easily used by community groups to document their food environment and target areas for positive change. There is a need for more research to understand the drivers of low F&V intake, more evidence-based programming in LMICs, and more global nutrition advocacy around this important issue.

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